Application of Jute Fiber in the Improvement of Subgrade Characteristics

Praveen Aggarwal[1], Bajinder Sharma[2]
[1] Civil Engineering Department, NIT Kurukshetra, India
Email: Praveen_agg@hotmail.com
[2] Civil Engineering Department, Govt. Polytechnic Nilokheri, Kurukshetra, Imdia
Email: bajinder2000@yahoo.co.in

***Abstract*—For the development of any country, a satisfactory mode of transport and communication is indispensable. This can be achieved through a transportation system, which is economically viable. Economy in road network can be achieved through economical pavement design. The entire load coming over the infrastructure is ultimately transmitted to the subgrade. Load carrying and dispersion capacity of subgrade soil play a vital role in civil engineering. In case of highway a weak subgrade results in greater thickness of pavement layer, so that the stresses on the subgrade are inconsonant with their load carrying capacity. Empirically flexible pavements are designed on the basis of CBR value of the subgrade and traffic on the proposed road. As per IRC recommendation increase in CBR value from 2.0% to 5.0% reduces the thickness requirement by 35% for 1.0 msa of traffic. Therefore improvement in subgrade has always been an area of concern to highway and geotechnical engineers. In the present study a series of Proctor Compaction tests and California Bearing Ratio tests have been carried out on soil mixed with jute fiber. Jute fibers of different diameters (2 to 8mm) and lengths (0.5 to 2.0 mm) are mixed in the subgrade in different percentage (0.2 to 1.0%) to find out the optimal quantity. Proctor and CBR test results are presented in the paper.**

***Index Terms*—Subgrade, Proctor Compaction, California Bearing Ratio**

I. Introduction

For the development of any country, a satisfactory mode of transport and communication is indispensable. This can be achieved through a transportation system, which is economically viable. Economy in road network can be achieved through economical pavement design. Quality of subgrade available is the input parameter in pavement design. Practically it is not possible to have good subgrade always. Poor subgrade necessitates a greater pavement thickness resulting in increased construction cost.

With the aim of reducing pavement thickness on poor subgrade new techniques of construction and soil stabilization have been continuously explored. Poor natural soils make them practically unsuitable for many civil engineering construction activities including road pavements. In such cases natural soils are being treated with different kinds of materials to improve their engineering properties. The techniques of improving the engineering properties of soil are called soil stabilization, which has been quite successfully used in many engineering problems.

In the present study jute fiber is used to improve the engineering properties of the subgrade, so that required pavement thickness may be reduced for particular traffic intensity. Jute fibers of different diameters and lengths were mixed in the subgrade in different percentage and the improvements in the subgrade are studied in terms of California Bearing Ratio (CBR).

II. Reinforced Earth

Blending of two or more than two materials is quite common, in order to obtain better engineering properties such as reinforced concrete [1]. In the same context reinforced earth is not an unusual phenomenon. Reinforcing the earth with randomly mixing of discrete fibers attracted considerable attention. From the economy point of view also, in an ideal conditions the cost of conventional structure may be reduced up to 50%.

We have several examples of reinforcing the soil like Great Wall of China (earliest example of reinforced earth using branches of trees as tensile materials), ziggurats of Babylon (woven mats of read were used) etc. In USA & Europe, the erosion & stability of slopes for highway and railway embankment is controlled using reinforced soil [2].
In India the concept of reinforced earth is comparatively new. The first national workshop on reinforced soil was held in 1985, under an aegis of Central Board of Irrigation and Power (CBIP). Since then the subject began to be commonly discussed at various Indian Geotechnical Conferences organized by CBIP, Geotechnical society institute of engineers, Textile association etc. The CBIP also organized an international workshop on reinforcing soil with textile in 1989 at Bangalore. The efforts are being made to make the concept popular but still it requires much to be done in this regard.

Since the invention by Hennery Vidal in 1966, nearly 4000 structures have been built in more than 37 countries so far using the concept of earth reinforcement. Reinforced soil structure may be cost effective alternative for conventional sloped embankment, gravity walls or RC cantilever walls when right of way is restricted, foundation conditions are weak and neither conventional walls can be built nor embankments with slopes [3][4].

III. Material Used

The soil used in this study is collected from National Institute of Technology Kurukshetra campus. The soil sample is collected from a depth of 60cm after removing the top

DOI:1.IJTUD.01.01.41

surface soil from natural ground surface. The jute fibers used in this study is purchased from the market in the woven form in the diameter of 2-3 mm and 6-8 mm. The fiber was coated with bituminous layer in order to protect it from decay. The bitumen used for the coating of jute fiber is of 80-100 grades. List of the materials used are given below: -

1 Soil
2 Jute Fiber
3 Bitumen

A. Soil

Index properties of the soil are determined (Table – I) and classification of soil is done as per Indian standard i.e. IS: 1498 & IS: 2720. The soil is classified as inorganic clay with low plasticity i.e. CL & has very soft consistency.

TABLE I. INDEX PROPERTIES OF THE SOIL

Color	Brown
Natural Water Content (%)	6.25
Liquid Limit (%)	29.95
Plastic Limit (%)	22.85
Consistency Index (%)	3.33
Maximum Dry Density (γd) (gm/cc)	1.98
Optimum Moisture Content (%)	13.0
Specific Gravity (GS)	2.70
C B R (at 2.5mm) (%)	1.82

B. Jute

The Jute fiber used is procured form the local market. The diameter of the thread varies between 2 mm to 10 mm. These fibers are generally available in the threaded form. These are mechanically woven fibers with very fine threads. Specific gravity and diameter of the jute fiber are shown in Table- II.

Jute industry is one of the oldest industries in India, has traditionally been used for packaging. However its versatility is coming to light now after the world had started looking for natural options to save the environment. Jute is a coarse natural hast fiber. The major components in a Jute fiber are given below [5]:

C. Bitumen

Bitumen is used for coating the jute fiber to protect them from microbial attack & degradation. Bitumen coating is done in the hot state at a temperature of 160°C. Grade and some of the other properties of bitumen are tabulated in Table-III.

TABLE II. PROPERTIES AND CONSTITUENTS OF JUTE

Color	Yellowish brown
Specific Gravity (G_J)	1.12
Diameter Used (mm)	2 - 8
Hoiocelluiose (%)	83-87
Lignin (%)	12-14
Wax (%)	0.4 to 0.81
Ash (%)	0.5 to 1.04
Nitrogen (%)	0.4

TABLE III. PROPERTIES OF BITUMEN

Grade	80-100
Softening Point (°C)	65
Flash Point (°C)	185
Specific Gravity (G_B)	1.06

IV. EXPERIMENTAL PROGRAM

A series of proctor compaction tests and California Bearing Ratio tests have been carried out on soil mixed with jute fiber. The detailed procedure and results are as under.

A. Proctor Compaction Test

To assess maximum dry density (MDD) and optimum moisture content (OMC) Standard Proctor compaction test is performed as per IS 2720: Part VII: 1980.

The Jute fiber purchased from the market in the diameter range of 2-3 mm, 4-5 mm and 6-8 mm has been cut in the pieces of length nearly 1.0m. These pieces of the jute are coated with bitumen in order to protect it from microbial attack & degradation. To coat the bitumen over jute fiber, bitumen is heated up to a temperature of nearly 160ºC. The thread of jute is dipped in it for about 2 to 3 second & extra bitumen is streamed off with the help of fork. The pieces in the way are left for cooling of 24 hour. After 24 hour the threads are further cut in the small pieces of length equal to 0.5cm, 1.0cm, 1.5cm and 2.0cm.

A series of standard proctor's tests are carried out on the soil sample with 0.2% to 1.0% by weight of jute fiber coated with bitumen. While adding the jute fiber coated with bitumen in the soil mass, appropriate correction is applied to cater for the amount of bitumen.

To study the effect of diameter and length of jute fiber, diameter is varied from 2 to 8 mm and length from 5.0mm to 20.0mm respectively.

From the result of proctor test it can be observed that the diameter of jute fiber 2-3 mm or 6-8 mm does not make any appreciable trend on the result of optimum moisture content and maximum dry density. Hence diameter of jute fiber is no more a study variable in the California bearing ratio tests.

DOI:1.IJTUD.01.01.41

B. California Bearing Ratio Test

A series of California bearing ratio (CBR) tests were performed on the soil without jute fiber reinforcement and with different proportion of jute fiber based on the standard proctor test results. The test is performed for all the combination of the lengths of jute fiber and percentages. The results are given below in the tabular form: -

TABLE IV. CBR VALUE OF UNREINFORCED AND JUTE FIBER REINFORCED SOIL AT RESPECTIVE MDD

JUTE (%)	0.2%	0.4%	0.6%	0.8%	1.0%
LENGTH	Without reinforcement at MDD - 1.82				
5mm	2.48	2.72	4.03	3.74	2.93
10mm	3.11	3.16	3.26	4.62	3.61
15mm	2.40	2.57	3.06	3.11	3.05
20mm	2.84	3.26	3.99	2.96	2.81

V. Results and Discussion

Results of jute fiber reinforced soil are compared with that of plain soil sample in two groups as: -

1. Effect of the jute reinforcement on the maximum dry density and optimum moisture content.
2. Effect of the jute reinforcement on California bearing ratio.

A. Effect of the jute reinforcement on the MDD and OMC

The Proctor's tests results obtained from the tests conducted on the soil sample without jute fiber and with different percentage of jute fiber of varying lengths and diameter (Figure 1) are discussed as below:

It is observed that inclusion of jute fiber reduces the MDD and increases the OMC.

With addition of 0.2% of jute fiber (2-3 mm diameter and 5mm length) the maximum dry density reduces from 1.98 gm/cc to 1.88 gm/cc, whereas the optimum moisture content increases from 13% to 15%.

MDD reduces from 1.88 gm/cc (with 0.2% of jute fiber) to 1.80gm/cc (with 1.0 % of Jute fiber), whereas there is an increase in OMC from 13.5 to 15.5% with inclusion of 0.2% to 1.0 % jute fiber in the subgrade soil.

Similar affects are observed with 10 mm long jute fibers.

It is also observed that diameter of the fiber does not have much effect on the maximum dry density and optimum moisture content.

B. Effects on the California Bearing Ratio

The following results are obtained from CBR tests performed on the soil samples mixed with different percentage of jute fiber (Table - IV): -

The CBR value for plain soil sample increases from 1.82 to 2.48 with 0.2% of 5mm long jute fiber.

Maximum CBR value is observed as 4.62% (with 10mm long, 0.8% jute fiber), an increase of more than 2.5 times the plain soil CBR value of 1.82%.

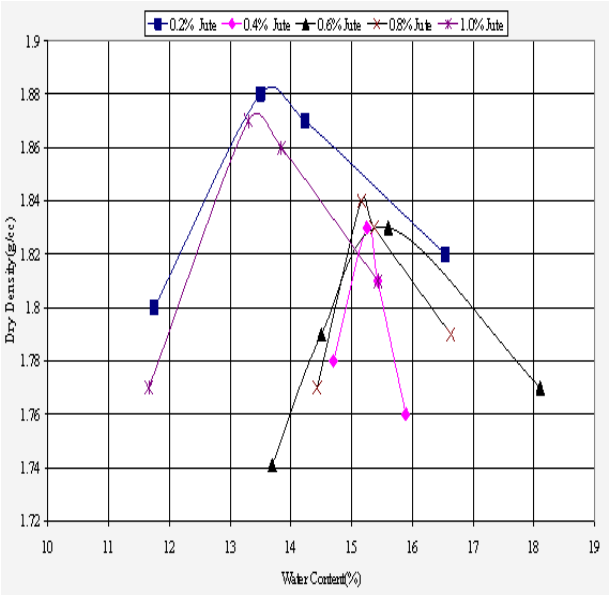

Figure – 1 Proctor test results on soil mixed with 2-3mm diameter 10mm length jute fiber in different percentages

Test results indicate that with 0.8% jute fiber (without bitumen coating) CBR value increases as high as three times that of the soil sample i.e. 5.53%. The other values corresponding to the 0.2%, 0.4%, 0.6%, and 1.0% of jute fiber are 3.79, 3.85, 4.97, and 4.42% respectively.

Conclusions

From the above discussion it can be concluded that jute fiber reinforcement reduces the maximum dry density and increases the optimum moisture content of the subgrade soil. The CBR value of the subgrade soil increases up to 250% with the inclusion of bitumen coated jute fiber.

References

[1] Bell, J.R. "Construction and Analysis for a fabric reinforced embankments", Proce. Int. Conf. Use of Fabrics in Geotechnics, Paris, 1997.

[2] Rao, P.J. "Jute Geotextile for improving the performance of Highway Embankment on soft Marine Soil", Proc. Nat. Sem, on Jute based Geotextiles, New Delhi, 1996.

[3] Juyol. G.P., Sastry, G. and Rao. M.S.R.M. "Rehabilitation of a mined area in Himalaya by Geojute and other measures". Proce. 5th Int. Conf. On Geotextiles, Geometric and Related Projects, Singapore, 1994.

[4] Azeem, A. and Ati, A. "Erosion and Control techniques for Slopes of Banks and Cuttings". Proc, Indian Geotechnical Conference. Vol. I, Calcutta, 1992.

[5] Website for jute fiber used www.jute.com.

DOI:1.IJTUD.01.01.41